ARMORED MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

PROJECT NO. 1 - COLD WEATHER OPERATIONS

Report On

Sub-Project No. 1-10, Analysis of Position of Armored Force Personnel in Respect to Winter Protection with Recommendations for Use and/or Design of Suitable Equipment and Food.

Project No. 1-10

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1. PROJECT NO. 1 - Cold Weather Operations. Sub-Project No. 1-10, Analysis of Position of Armored Force Personnel in Respect to Winter Protection with Recommendations for Use and/or Design of Suitable Equipment and Food.

a. Authority - Letter Commanding General, Headquarters Armored Force, Fort Knox, Kentucky, File 400.112/6 GNOHD, dated September 24, 1942.

b. Purpose - To determine the influence of various seating arrangements and the compressibility of certain pile fabrics on the comfort of men in the cold.

2. DISCUSSION:

a. The relative capacities of men to maintain comfort, while sitting quietly in the cold and dressed in moderately good clothing, vary greatly and are determined primarily by the individual and varying responses of the men involved. Superimposed upon this variation, however, are secondary factors which may also influence reactions. One such factor is the type of seat and the thermal properties of the materials of which it is constructed. Another is the loss of clothing insulation over the compressed areas produced by pressure of the body against the supporting seat.

b. Armored personnel operating in cold environments are faced by a problem peculiar to vehicular troops. Not only must they remain seated for long periods of time, frequently with a limited amount of movement, but they are also surrounded by masses of metal having extremely high conductivity and are generally provided with seats also made of steel. To improve the steel seats with respect to heat loss, insulating pads have been added but these are generally lost. Suggestions have been advanced for the adoption of seats made of other materials, such as wood or webbing, of lower thermal conductivity.

Tests have been conducted to determine the relative advantages of the following types of seats:

(1) Flat topped wooden stool
(2) Flat topped metal half track seat, with and without cushion, with and without padding in the cushion.
(3) Bucket seat of the type being installed in M-4 tanks, with and without cushion.
(4) A web seat made of textile netting supported on the frame of a lawn chair.

c. In the Arctic clothing assembly the insulation is mainly obtained by trapping layers of air between the garments. The pile garments are responsible for the formation of the largest static air reservoir. The longer the

pile, the thicker, although not necessarily more static, is the trapped air layer. When the clothing assembly is put under pressure, the compression reduces the thickness of the air layer with consequent reduction in insulation. Thus, relative resistance to compression is an important characteristic of pile fabrics. The thickness of the air layer remaining after compression should be greater with the longer pile. Three thicknesses of pile were investigated - 3/8, 1/2 (standard) and 5/8 inch.

d. Details regarding the seats and test procedures will be found in the Appendix.

3. CONCLUSIONS:

a. The two best seats were the insulated bucket seat and the half track seat with extra padding.

b. The same two seats, without insulating pads, and the textile webbed seat were the poorest.

c. While methods employed did not permit accurate determination of the relative value of the three thicknesses of pile, there appeared to be no significant differences between them.

4. RECOMMENDATIONS:

a. That padded bucket seats of the type now installed in the M-4 Tank, or equivalent be considered for adoption for other vehicles employed in cold weather operations.

b. That some means be found which will keep insulating pads attached to seats.

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#1 - Appendix
#2 - Tables I & II
#3 - Figs. 1 thru 7

Six (6) subjects were employed in the study, at ambient temperatures of 0, -10 and -33°F and zero wind velocity. They sat for periods of three hours in the cold room in seating arrangements described best by the photographs inclosed (Figs. 1 to 4). They were dressed in a standard Arctic zone clothing assembly, viz:

Drawers, Wool 50/50
Undershirt, Wool 50/50
Shirt, Flannel, O.D.
Trousers, Field, Wool, O.D.
Trousers, Field, Pile 50/50 sateen 9 oz.
Parka, Field, Cotton, O.D. Sateen 9 Oz.
Parka, Pile 50/50
Shoe, Arctic, Felt
Socks, Wool, Ski (2 pairs)
Socks, Wool, Cushion (1 pair)
Mittens, Insert, Trigger finger, M-1943
Muffler, Wool
Wristlets, Knit

The basic issue was modified by substituting experimental pile or outer windproof garments. A summary of the seat tests and the clothing worn is presented in Table I. These tests were conducted in conjunction with primary tests of several modifications of the standard clothing and were incidental thereto. Hence, the great variety of clothing combinations, as shown in the Table.

Three of the subjects (Ch., Fa., and Go.) were cold resistant individuals while the other three were considered to be cold susceptible. A better term for this latter group might be "variable reactors". The first three men experienced no real discomfort with any of the seats or clothing combinations tested. Their evaluation of the seats appeared to be based on a vague sense of discomfort associated with localized cooling in the buttocks and back. The remaining three men were definitely made more uncomfortable by some seats than by others. Their opinions consequently were influenced to a marked degree by general body cooling as well as the localized chilling.

At the cessation of the experiments during which the standard Arctic assembly was being worn, the subjects were asked to evaluate the different seats (Table II). There is no doubt as to which seats were the best and which the poorest. The padded bucket-type seat presently used in the M-4 series medium tank was considered to be the finest seat available. When men were given free choice in the matter of seats during later tests, for other projects, difficulty was experienced in satisfying six men because only two of these bucket seats were available.

Any seat that is either heavily padded or lightly padded but properly designed for seated individuals is thermally satisfactory. The padding is essential not only to insure postural comfort but also to minimize the rate of local cooling and sensations of cold in supported areas such as the buttocks and back. With the unsatisfactory seats the subjects stated that their buttocks were not only cold within five to ten minutes after being seated but that they never became warm during the three-hour exposure. With both of the padded seats and the wooden stools the buttocks were cold during the first few minutes but this sensation was rapidly replaced by one of comfort. Painful cold in the buttocks was recorded in only one subject, and that while he was seated in the

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cushionless bucket seat.

Shivering started much sooner in certain of the seats than in others. With a poor seat, the discomfort occasioned by early and continuous shivering was most marked. In some instances the hands and feet also became cold with pain more rapidly. The subjective responses of the three more susceptible subjects while seated in several of the experimental seats are shown in Fig.5.

When insulative padding was provided for the steel seats, the comfort of men was influenced to a relatively minor degree by compression of the clothing. With bare unpadded seats, on the other hand, compression of fabrics was more important but in turn dependent upon the area compressed. The smaller this area,the more negligible is the effect on either overall thermal insulation or on subjective comfort. On the wooden stools the loss in insulation, owing to compression, was undoubtedly counterbalanced in large measure by the poor conductivity of the wood and its effect minimized by the small area involved. However, with the compression produced in unpadded metal seats, the reduction in insulation becomes of major importance because of the larger compressed area involved and the high conductivity of the steel. These result in the onset of discomfort in a very short time. The bucket seat was the greatest offender in this respect because it is so designed that the weight of the torso is distributed over a large buttock area with consequent greater area of contact and resulting increase in the extent of both compression and conductivity. Flat topped seats generally have limited area under compression which explains why the bare half track seat was found preferable to the unpadded bucket seat.

The web seat was made of textile netting having a closely spaced web. This resulted in an intensive and extensive compression of the dorsal surface of the clothing from head to knees but with no compensating insulation in the supporting web. Cooling was extremely rapid. All but two men, both resistant subjects were very uncomfortable in this seat. Previous to the tests, all of the subjects had remarked on the comfortable appearance of this chair but none of them were anxious for a repeat exposure.

Temperature measurements were made on several subjects during the seat tests. In Fig. 6 are shown skin temperature curves obtained on the thighs of a subject seated in a padded and in a non-padded steel seat. The lowering of the skin temperature on the dorsal thigh in the non-padded metal seat is striking. Skin temperatures obtained on the same areas while the subject was seated on a stool, showed maximum differences between the ventral and dorsal thighs of only 2.5°C and after three hour exposure sitting on the stool the lowest temperature recorded on the dorsal thigh was 28.5°C. The relative changes in the skin temperature of the chest and back while seated in the web seat, and the bucket-type tank seat are shown in Fig. 7. It is interesting to note,in the figure, that as soon as compression is relieved by sitting erect, the skin temperature of the back rises rather rapidly and returns to the previous low level very quickly when the man sits back in the seat and the garments are recompressed. Since these are only single points on each of the surfaces, these temperature data must be considered as being only indicative of changes.

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Differences between the three thicknesses of pile or any of the outer garment combinations were of such magnitude as to be insignificant. Unfortunately the methods employed were only capable of detecting rather gross differences. Finer distinctions can be made with more complex methods but the differences found scarcely appear to warrant such an investigation.

For vehicles which are to operate in low temperatures it is necessary to design seats not only for the sitting comfort of the man but also to provide heat insulation to offset that lost by compression of the clothing. A seat properly designed for correct posture is made in such a fashion that the weight of the torso is distributed over a large portion of the buttocks. This type of seat requires extreme care in the fitting of insulating pads, therefore, if it is to retain its comfort features from the standpoint of cold protection as well as posture. As a practical matter, suitable measures should be taken to prevent loss of the insulating padding so provided.

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TABLE I

SUMMARY OF EXPERIMENTS DURING WHICH DIFFERENT CLOTHING WAS WORN
WHILE MEN SAT ON VARIOUS TYPES OF SEATS

TYPE* OF CLOTHING WORN	TYPE SEAT													
	TANK WITH PAD		TANK-NO PAD		HALF TRACK-PAD		HALF TRACK-FULL PAD		HALF TRACK-NO PAD		WEB SEAT		WOODEN STOOL	
	No of users	No of times used	No of users	No of times used	No of users	No of times used	No of users	No of times used	No of users	No of times used	No of users	No of times used	No of users	No of times used
A	7	30	6	8	4	4	3	5	6	6	7	11	10	51
B	1	1			1	1							4	5
C	4	6	1	1	2	2			2	3	3	4	4	5
D											2	2	1	1
E													2	3
F	1	1			1	1	1	1			2	2	3	4
G	2	2			1	1					2	3	3	4
H													1	1
I													1	2
J													5	9
K	3	3	1	1	1	1			1	1	3	4	1	1
L													6	6

* TYPE OF CLOTHING

A - Sateen 9 oz.
B - Sateen 9 oz. with Zipper Front plus Pile Parka with Zipper
C - Sateen 9 oz. plus 5/8" Pile or 3/8" pile
D - Sateen 9 oz. plus Napped Pile
E - Sateen 9 oz. with all openings closed
F - Cloth, Herringbone Twill 8.5 oz.
G - Cloth, Cotton Uniform, Khaki Twill
H - Nylon
I - Sateen 9 oz. under 1/2" Pile
J - Napped Sateen and Napped Pile
K - No wind breakers
L - Sateen 9 oz. and Pile Jacket

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TABLE II

COMFORT RATINGS OF SEVERAL SEATING ARRANGEMENTS

BY SIX SUBJECTS

Type of Seats	Subjects					
	Ch	Fi	Di	Ti	Fo	Go
Bucket-type with cushion	1	1	1	1	1	1
Half track with heavily padded cushion	2	2	2	2	2	2
Wooden stool	4	3	3	3	5	4
Half track with cushion	3	4	3	4	3	5
Bucket-type without cushion	5	5	5	6	7	6
Half track without cushion	6	6	6	5	6	7
Lawn chair	7	7	7	7	4	3

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Wooden stool used as control seat

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Figure 1

[illegible] seat now being installed in M-4 tanks.
Note that buttoned on cushion may be easily lost.

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Project [illegible]-10 Figure 2

The lawn chair showing the textile netting
(jungle hammock) used to produce a web seat

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Figure 3

Half-track seat - showing the loose unpadded cushion

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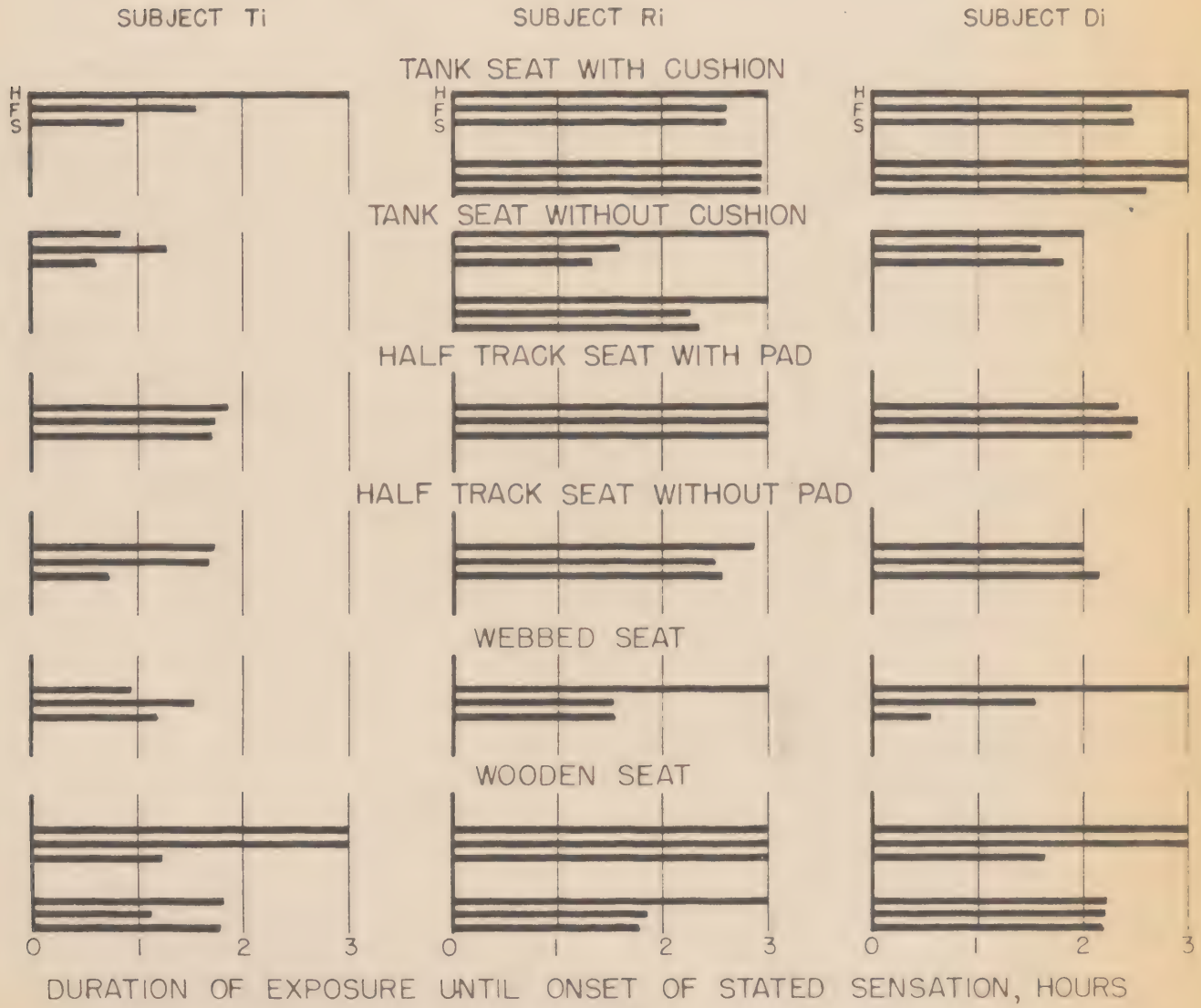
Figure 4

FIG. 5

SUBJECTIVE REACTIONS OF MEN DRESSED IN STANDARD ARCTIC ASSEMBLY EXPOSED TO -10° F AND ZERO WIND VELOCITY



- KEY -

F = ONSET OF PAIN IN FEET
H = ONSET OF PAIN IN HANDS
S = ONSET OF SHIVERING

EXTENSION OF LINE TO 3 HRS. INDICATES NO STATED SENSATION DURING EXPOSURE

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FIG. 5

FIG. 6

SKIN TEMPERATURE ON THIGHS

SITTING IN PADDED AND UNPADDED STEEL SEAT
TEMPERATURE -10° F

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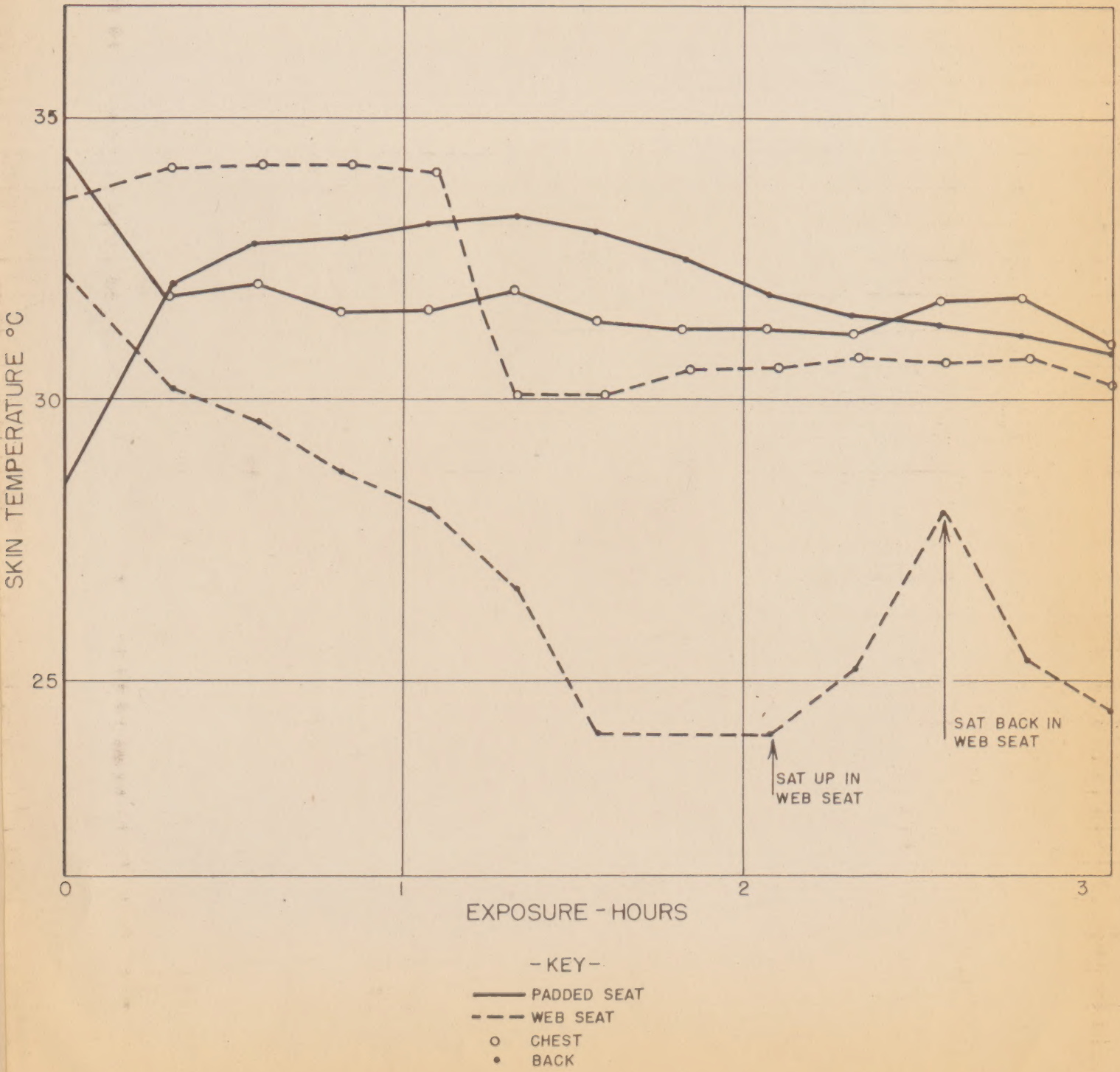
FIG. 6

FIG. 7

SKIN TEMPERATURE OF TORSO OF SUBJECT EXPOSED TO -10° F
SITTING IN WEB SEAT AND IN SEAT WITH A BACK PAD



Seal #3

FIG. 7